Progress Report - Pamet River Study
Contract Number CX1600-4-0045

July 23, 1985

This report is made pursuant to Contract Number CX1600-4-0045. The amount charged to the Department of the Interior, National Park Service, for the work resulting in this report (inclusive of the amount so charged for any prior reports submitted under this Contract) is $9832. The name of the person employed by the Contractor with managerial and professional responsibility for such work is Richard C. Toner.

Introduction

This is the second progress report covering studies by Marine Research, Inc. (MRI) of Falmouth, Massachusetts, on the upper Pamet River in Truro, Massachusetts. The work is being conducted under National Park Service Contract Number CX1600-4-0045 in accordance with a proposal from MRI dated June 11, 1984 which was prepared in response to RFP NARO-4-0036.

The first progress report was submitted January 29, 1985 and covered the autumn sampling in October 1984.

This progress report describes the winter and spring sampling activities carried out in February and April respectively, and the spring river flow measurements in May 1985. Figure 1 shows the three Pamet River stations (1-3), six privately-owned primary wells (A-F), and six secondary wells - four being privately-owned (G-J) and two shallow wells driven by MRI near Ballston Beach (K and L). Table 1 summarizes the parameters analyzed at each location. This report includes an account of the methodology derived from the publication by American Public Health Association et al. (1980).

Summer sampling commenced June 12 and will terminate August 21; additional river flow measurements will be made during this summer period. Comparative results and interpretation of all data will be presented in the final report to be submitted October 31, 1985.

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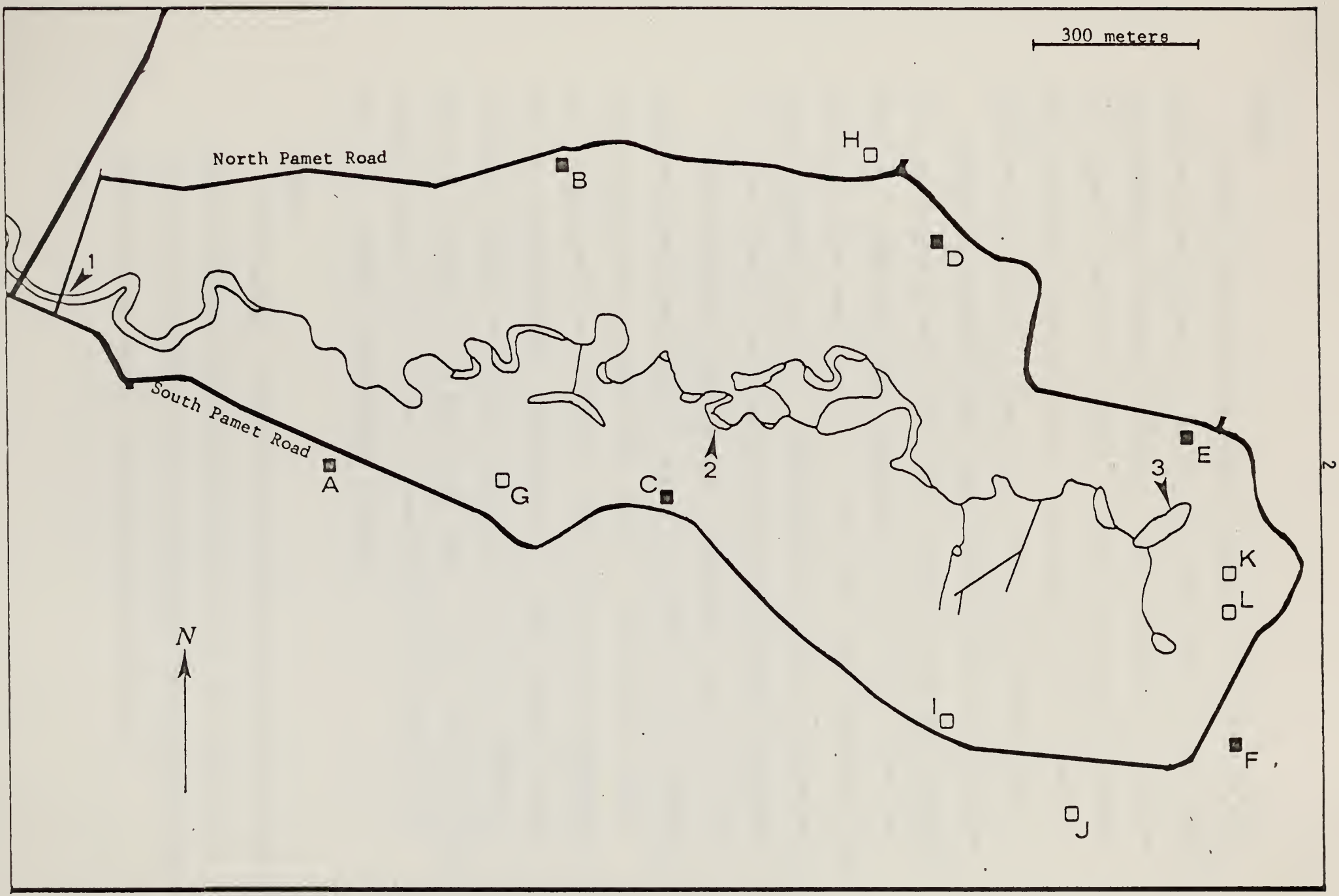

Figure 1. Upper Pamet River sampling stations (1 - 3), six primary sampling wells (A - F), and six secondary sampling wells (G - L).

Methods

At each of the three river stations phytoplankton populations were determined by collecting a one-liter water sample which was fixed with 0.5% glutaraldehyde for subsequent analysis. In the laboratory the plankton were allowed to settle for 24 hours, the bulk of the water was siphoned off, and the cells were identified and enumerated on a hemacytometer. Phytoplankton densities were expressed as number of cells per liter.

Sampling of algae and rooted vegetation was carried out within one-meter square quadrat areas spaced across the river at the three sampling stations. A 50-mm core sample was analyzed for microscopic algae from each of the three quadrat areas at Stations 1 and 2 and from three of four quadrats sampled at Station 3. Approximately 1.8 liters of bottom sediment were sieved (2 mm) at each station to qualitatively sample macrobenthos.

Field measurements of temperature, conductivity, pH, and dissolved oxygen were made using a Hydrolab digital model 4041. In the laboratory pH was measured with a Corning model 7 meter. All laboratory colorometric measurements were made with a Beckman model 24 spectrophotometer. The American Public Health Association et al. (1980) recommends several alternative methods for laboratory analysis of the various parameters which are of concern in the Pamet River study. A brief discussion of the methods utilized by MRI follows; for more detailed descriptions, the reader is referred to the published transcript.

Acidity

Water samples for acidity determination are collected in 250-ml plastic containers and immediately placed on ice in a cooler; upon return to the laboratory they are refrigerated until analyzed which routinely occurs within 6 to 24 hours after collection.

Acidity is measured using 100-ml samples which are brought up to a temperature range of 68-78°F. The contents are stirred gently and slowly titrated with 0.02 normal (N) sodium hydroxide (NaOH) to a pH of 8.3. Results are expressed as mg per liter of calcium carbonate.

Alkalinity

Alkalinity determinations are made on a portion of the samples collected for acidity determination. Titration is made with 0.02 N sulfuric acid (H_2SO_4) to a pH of 4.5. The results are expressed as mg per liter of calcium carbonate.

Chloride

Samples of water are collected in 250-ml plastic containers with no preservative being necessary. Because the river stations and primary wells contain between 0.15 and 10 mg chloride or more per 100-ml sample, silver nitrate ($AgNO_3$) is utilized for titration.

Aluminum

Water samples for aluminum analysis are collected in 500-ml glass containers which have been acid cleaned and rinsed with distilled water. Imediately after collection 2 ml of nitric acid (HNO_3) per 100 ml of water are added to the sample. Analyses are carried out by GHR Analytical, Inc. of Lakeville, Massachusetts, using the flame atomic absorption method.

Sulfate

Sulfate samples are collected in 250-ml plastic containers, immediately placed on ice in a cooler, and upon return to the laboratory are refrigerated until analyzed. The turbidimetric method is used for sulfate determination because the minimum detectable concentration is 1 mg SO_4/l.

In this method sulfate ions are precipitated in a hydrochloric acid (HCl) medium with barium chloride ($BaCL_2$) so as to form barium sulfate crystals ($BaSO_4$) of uniform size. Light absorptance of the barium sulfate suspension is measured by spectrophotometry operating at 420 nm over a light path of 5 cm.

Iron

Water samples for iron analysis are collected in 250-ml plastic containers and immediately placed in an ice chest for storage pending analysis. Within six hours after collection the sample is filtered through a 0.45 μ Millipore filter and the filtrate containing ferrous ions is stabilized with 1 ml hydrochloric acid (HCl) per 100 ml of sample. A spectrophotometer utilizing a 5 cm light path measures the orange-red complex that results from ferrous iron-phenanthroline mixture in an acid condition. Ferrous iron concentrations between 0.02 and 4.0 mg/l can be determined directly and higher concentrations, if necessary, can be determined using aliquots.

Ammonia

Nutrient samples are collected in 500 ml plastic containers which are immediately placed on ice. Within 5 to 6 hours after collection the samples are filtered through a Whatman microfibre glass filter, and 100 ml of the filtrate is immediately frozen until analysis for ammonia content. An additional 250 ml is frozen for nitrate and phosphorus determination described later.

The Nesslerization method is utilized for ammonia determination and is sensitive to 20 μg NH_3-N/l under optimum conditions and may be used for up to 5 mg NH_3-N/l. Pretreatment of the sample with zinc sulfate ($ZnSO_4 \cdot 7H_2O$) and alkali precipitates calcium, iron, magnesium,

and sulfide. The addition of the Nessler reagent consisting of mercuric iodide (HgI_2) and potassium iodide (KI), reacting with the ammonia-nitrogen in the sample, yields a yellow-colored sample when the ammonia-nitrogen ranges between 0.4 and 5 mg/l. The ammonia-nitrogen concentration is measured by a spectrophotometer operating at 420 nm over a 5-cm light path.

Nitrate

A portion of the nutrient filtrate, which has been collected, filtered, and frozen as described above, is utilized for nitrate determination. Nitrate is reduced to nitrite in the presence of cadmium. The nitrite produced is determined by diazotizing with sulfanilamide and N-(1 naphthyl)-ethylenediamine to form a highly colored azo dye which is measured in a spectrophotometer at 543 nm at a 5-cm long light path. This method is recommended for nitrate levels below 0.1 mg N/l which is typical of the Pamet watershed values.

Silica

A portion of the frozen nutrient filtrate is used to determine molybdate-reactive silica (SiO_2). At a pH of approximately 1.2 ammonium molybdate reacts with silica and any phosphate present. Oxalic acid is added to destroy the molybdophosphoric acid but not the molybdosilicic acid. The intensity of the resulting yellow color is proportional to the concentration of molybdate-reactive silica which is measured with a spectrophotometer at 410 nm at a light path of 5 cm. This method is recommended for water samples containing from 0.4 to 25 mg SiO_2/l using dilutions and may be used for water having lesser silica concentrations which is true of the Pamet samples.

Phosphorus

A 50-ml sample of nutrient filtrate is used for determining phosphorus known as dissolved orthophosphate. Ammonium molybdate and potassium antimonyl tartrate react in an acid medium with orthophosphate to form heteropoly acid-phosphomolybdic acid which is reduced to intensely colored molybdenum blue by ascorbic acid. The concentration of dissolved orthophosphate is measured by a spectrophotometer at 880 nm over a 5-cm light path.

Total phosphorus

A 250-ml water sample is collected in a plastic container and placed immediately in an ice chest where it is stored until return to the laboratory where the sample is frozen. At the time of analysis the sample is thawed and 50 ml undergo persulfate digestion with ammonium persulfate ($(NH_4)_2S_2O_8$). Following digestion, the sample is treated as previously described for phosphorus determination.

Bicarbonate ions, carbonate ions, and free carbon dioxide

A 250-ml sample is collected in a plastic container and immediately placed in a cooler. The sample is analyzed within 6 to 24 hours after collection. At that time 100 ml of the sample are brought up to a temperature range of 68-78°F and immediately titrated to a final pH of 4.5 with 0.02 N sulfuric acid (H_2SO_4) which will provide an alkalinity measurement expressed as mg calcium carbonate per liter.

The calcium carbonate concentration is converted to milli-equivalents of hydrogen ions per liter. Using the milli-equivalents of the hydrogen ion, the pH and salinity of the original sample, the concentration of bicarbonate ion, carbonate ion, and free carbon

dioxide is determined using the table found in Strickland and Parsons (1972). For a complete understanding of the bicarbonate, carbonate, and carbon dioxide system, the reader is referred to Stumm and Morgan (1981).

River Flow Volume and Residence Time

An assessment of the volume of water which leaves the upper river through the Route 6 conduit was carried out on May 14th as being representative of springtime river flow characteristics. The time at which the current flow reversed from "in" to "out" in the morning in the conduit was determined by observing the change in direction of rotation of a flowmeter (General Oceanics model S2030-R2) which was positioned in the conduit. The depth of water in the conduit and the speed of water flow as measured by the flowmeter were recorded at that time and every half hour thereafter throughout the day during the ebbing period until the flow again reversed, changing from "out" to "in".

As a method of aiding in the determination of residence time of the river, a batch of Rhodamine WT dye was injected into the water near the youth hostel at the time of mean high water in Cape Cod Bay. Following injection of the dye, a Turner model 111 fluorometer was set up at the conduit to continually monitor for the presence of dye in the water passing through the conduit during the ebbing stage.

These data are being analyzed and the results of this activity plus further studies dealing with the river flow characteristics will be presented in the final report.

Results

Results of the February and April sampling are presented in Tables 2-15 and, as mentioned in the Introduction, will be fully discussed in the final report. However, our findings to date indicate that measurements of alkalinity are worth noting at this time.

Alkalinity as expressed herein as mg of calcium carbonate per liter provides a measure of the acid-neutralizing capacity of the water. When acid is deposited into an aquatic system by rainfall, it is largely neutralized by the alkalinity until it is depleted. Thus the alkalinity "buffers" the water against large changes in pH which can be injurious to organisms. Over time, the alkalinity may be depleted by continued inputs of acid. Such is the case in many lakes and rivers in New England.

Surface waters with alkalinity between 10 and 20 mg/l of calcium carbonate, as determined by the method of the Environmental Protection Agency, are considered sensitive to this type of long-term acidification according to the classification by the acid rain monitoring project of the University of Massachusetts (Ruby and Godfrey 1985). In this study MRI employed "Standard Methods" (American Public Health Association et al. 1980) which produce results 1.5 to 2 mg/l higher than the EPA method. Therefore the results of October 1984, February and April 1985 indicate that the alkalinity of the Pamet River ranged between 10.98 and 24.40 mg/l with the majority of measurements being below 20 mg/l. The river with its buffering system would be characterized as a sensitive body of water in relation to alkalinity measurements.

Literature Cited

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1980. Standard Methods for the Examination of Water and Wastewater. 15th Edition. American Public Health Association, Washington, D.C. 1134 p.

Ruby, Armand III, and Paul J. Godfrey. 1985. A.R.M. Newsletter. Water Resources Research Center, University of Massachusetts, Amherst, MA. 4 p.

Strickland, J.D.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. Second edition. Fisheries Research Board of Canada. Bulletin 167. 311 p.

Stumm, W. and J.J. Morgan. 1981. Aquatic Chemistry, an Introduction Emphasizing Chemical Equilibria in Natural Waters. Second edition. John Wiley and Sons, New York.

Table 1. Sampling parameters and schedule for the upper Pamet River study.

		pH	Cond.	D.O.	Temp.	Acidity	CO_2	HCO_3^-	CO_3^-	Chloride	N*	P	SI	Fe	Sulfate	Al	Algae: Epipelic	Algae: Epiphytic	Algae: Planktonic	Macro-benthos	Rooted Vegetation
FALL (one time)	River Stations (3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Primary Wells (1-6)	x	x	x	x	x				x	x	x		x	x	x					
	Secondary Wells (7-12)	x	x		x																
WINTER (one time)	River Stations (3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Primary Wells (1-6)	x	x	x	x	x				x	x	x		x	x	x					
	Secondary Wells (7-12)	x	x		x																
SPRING (one time)	River Stations (3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Primary Wells (1-6)	x	x	x	x	x				x	x	x		x	x	x					
	Secondary Wells (7-12)	x	x		x																
SUMMER (see footnotes)	River Stations (3)	** ++	** ++	** ++	** ++	**	** ++	** ++	** ++	**	** ++	** ++	** ++	**	**	**	+	+	** ++	+	+
	Primary Wells (1-6)	**	** ++	**	**	**				**	**	**		**	**	**					
	Secondary Wells (7-12)	** ++	** ++		** ++																

* N = Ammonia, nitrate, nitrite.
** Sampled on six occasions from late June to early August.
\+ Sampling completed on one occasion in July.
++ Sampled on five additional dates, June and August.

Table 2. Phytoplankton abundance, expressed as millions of cells per liter, found at three sampling stations in the Pamet River, February 28, 1985.

	Station		
	1	2	3
Diatoms			
Amphiprora spp.		0.456	
Cyclotella spp.	1.536	1.368	0.356
Cylindrotheca closterium	0.128		1.280
Diatoma vulcare		0.152	
Diatoma spp.		0.304	
Naviculoid diatoms	0.384	0.760	0.128
Nitzschia spp.	0.256		
Skeletonema costatum	0.256		
Unknown diatoms	0.768	1.368	0.640
Dinoflagellates			
Unknown dinoflagellates	0.128	0.152	
Flagellates			
Calycomonas wulffii			0.256
Olisthodiscus luteus			0.384
Unknown flagellates	9.856	17.024	8.448

Table 3. Phytoplankton abundance, expressed as millions of cells per liter, found at three sampling stations in the Pamet River, April 22, 1985.

	Station		
	1	2	3
Diatoms			
Chaetoceros spp.		0.249	0.009
Cyclotella spp.	0.060		
Diatoma spp.	0.012	0.017	0.009
Gyrosigma sp.		0.009	
Naviculoid diatoms		0.009	0.019
Skeletonema costatum	0.048	4.386	0.047
Unknown diatoms	0.252		
Dinoflagellates			
Prorocentrum sp.	0.012		
Flagellates			
Euglena viridis	0.024		
Unknown flagellates	0.036	0.086	0.113

Table 4. Vegetation found, by quadrats, at three stations in the Pamet River, February 28, 1985.

Station	Quadrat	Species	Cover Class*	Category	Where found
1	1	No higher plants or macrophyte algae present			
	2	Zannichelia palustris**	1	sporophyte	Bottom
	3	mat of Ulothrix sp.	1	alga	Branches
2	1	No vegetation found			
	2	Potamogeton sp.	1	sporophyte	Bottom
		large tuberous rhyzomes with attached clumps of	1	sporophyte	Bottom
		Ulothrix sp.	1	alga	Branches
	3	Ulothrix sp.	1	"	"
3	1	Ice cover; mats of filamentous diatoms and blue-green algae were seen under the ice			
	2				
	3				
	4				

*

Cover class	Estimated percent cover
1	0 to 5%
2	6 to 20%
3	21 to 40%
4	41 to 60%
5	61 to 80%
6	81 to 100%

** This identification is still only tentative because the description does not fit perfectly. Z. palustris is listed as a very rare species of brackish or alkaline waters in New England. Until the plant flowers, it is not possible to be certain about the identification.

Table 5. Vegetation found, by quadrats, at three stations in the Pamet River, April 23, 1985.

Station	Quadrat	Species	Cover Class*	Category	Where Found
1	1	Cladophora sp.	2	alga	Plant debris and branches
	2	Zannichelia sp.	2	sporophyte	Bottom
	3	Potamogeton sp.	3	sporophyte	Bottom
2	1	Cladophora sp.	1	alga	Plant debris and branches
	2	rhyzomes with shoots	1	sporophyte	Bottom
		Cladophora sp.	1	alga	Plant debris and branches
	3	Cladophora sp.	1	"	"
		rhyzomes with shoots	2	sporophyte	Bottom
3	1	algal mat containing Melosira spp.	2	diatom	free-floating
		Ulothrix sp.		alga	Branches
		blue-green algae			
		bacteria			
	2	similar algal mat	2		
	3	No vegetation visible			
	4	algal mat	5		

*

Cover class	Estimated percent cover
1	0 to 5%
2	6 to 20%
3	21 to 40%
4	41 to 60%
5	61 to 80%
6	81 to 100%

Table 6. Diatoms found in core samples from the Pamet River, February 28, 1985.

Station 1, Quadrat 1

Diatoma sp.
Eunotia sp.
Fragilaria sp.
Frustulia sp.
Gyrosigma sp.
Melosira bindera
Melosira sp.
Navicula spp.
Pleurosigma sp.
Surirella sp.
Synedra spp.

Other plant species in core:

Closterium sp. (desmid)
Spirogyra sp. (green alga)
Ulothrix sp. (green alga)

Station 1, Quadrat 2

Diatoma sp.
Eunotia sp.
Fragilaria sp.
Frustulia sp.
Gyrosigma sp.
Melosira sp.
Navicula spp.
Nitzschia linearis
Pleurosigma sp.
Surirella spp.
Synedra ulna
Synedra sp.
Tabellaria sp.

Other plant species in core:

Oscillatoria sp. (blue-green alga)
Ulothrix sp.

Station 1, Quadrat 3

Cyclotella sp.
Fragilaria sp.
Melosira sp.
Navicula spp.
Nitzschia longissima
Plagiotropis lepidoptera
Synedra sp.

Other plant species in core:

Netrium sp. (desmid)
Oscillatoria sp.
Ulothrix sp.

Station 2, Quadrat 1

Diatoma spp.
Eunotia sp.
Frustulia sp.
Melosira spp.
Navicula spp.
Nitzschia sp.
Synedra ulna
Tabellaria sp.

Other plant species in core:

Spirulina sp. (blue-green alga)
Ulothrix sp.

Station 2, Quadrat 2

Actinella sp.
Cyclotella sp.
Diatoma sp.
Frustulia rhomboides
Gyrosigma sp.
Melosira sp.
Navicula linearis
Navicula spp.
Nitzschia sp.
Pinnularia sp.
Pleurosigma sp.
Synedra spp.
Tabellaria fenestrata
Tabellaria sp.

Other plant species in core:

Nostoc sp. (blue-green alga)
Oscillatoria sp.
Ulothrix sp.

Station 2, Quadrat 3

Actinella sp.
Amphora sp.
Diatoma sp.
Fragilaria sp.
Gomphonema sp.
Gyrosigma sp.
Melosira sp.
Navicula linearis
Navicula spp.
Nitzschia sp.
Synedra spp.
Tabellaria sp.

Other plant species in core:

Ulothrix sp.

Station 3, Quadrat 1

Amphiprora sp.
Amphora sp.
Diatoma vulgare
Diatoma sp.
Gyrosigma sp.
Melosira moniliformis
Melosira varians
Navicula spp.
Nitzschia linearis
Surirella sp.
Synedra spp.

Other plant species in core:

Nostoc sp.
Ulothrix sp.

Station 3, Quadrat 3 NO SAMPLING DUE TO THICK ICE

Station 3, Quadrat 4

Diatoma sp.
Eunotia sp.
Frustulia sp.
Melosira monoliformis
Melosira varians
Navicula spp.
Nitzschia linearis
Nitzschia sp.
Pleurosigma sp.
Surirella sp.
Synedra ulna
Synedra spp.
Tabellaria sp.

Other plant species in core:

Ulothrix sp.

Table 7. Diatoms found in core samples from the Pamet River, April 23, 1985.

Station 1, Quadrat 1

- Diatoma sp.
- Eunotia sp.
- Fragilaria sp.
- Frustulia sp.
- Gyrosigma sp.
- Melosira sp.
- Meridion sp.
- Navicula spp.
- Nitzschia sp.
- Pleurosigma sp.
- Surirella sp.
- Synedra ulna
- Synedra spp.
- Tabellaria sp.

Other species present:

- Ulothrix sp. (green alga)

Station 1, Quadrat 2

- Achnanthes sp.
- Cymbella sp.
- Diatoma sp.
- Eunotia sp.
- Frustulia sp.
- Gyrosigma sp.
- Melosira sp.
- Navicula spp.
- Nitzschia sp.
- Stauroneis sp.
- Surirella sp.
- Synedra ulna
- Synedra sp.
- Tabellaria sp.

Other species present:

- Spirogyra sp. (green alga)
- Ulothrix sp.

Station 1, Quadrat 3

- Coscinodiscus sp.
- Diatoma sp.
- Dimerogramma sp.
- Eunotia sp.
- Frustulia sp.
- Gyrosigma sp.
- Melosira varians
- Navicula spp.
- Nitzschia sp.
- Pleurosigma sp.
- Stauroneis sp.
- Surirella sp.
- Synedra ulna
- Synedra spp.
- Tabellaria fenestrata

Other species present:

- Oscillatoria sp. (blue-green alga)
- Ulothrix sp.

Station 2, Quadrat 1

- Diatoma sp.
- Eunotia sp.
- Fragilaria sp.
- Meridion sp.
- Navicula spp.
- Nitzschia sp.
- Stauroneis sp.
- Synedra ulna
- Synedra spp.

Other species present:

- Closterium sp. (desmid)
- Ulothrix sp.

Station 2, Quadrat 2

- Amphora sp.
- Cyclotella sp.
- Diatoma sp.
- Eunotia sp.
- Fragilaria sp.
- Gomphonema sp.
- Gyrosigma sp.
- Melosira sp.
- Navicula spp.
- Nitzschia sp.
- Plagiotropis sp.
- Stauroneis sp.
- Surirella sp.
- Synedra ulna
- Synedra spp.
- Tabellaria sp.

Other species present:

- Spirogyra sp.
- Ulothrix sp.

Station 2, Quadrat 3

Diatoma sp.
Dimerogramma sp.
Eunotia sp.
Frustulia sp.
Gomphonema sp.
Gyrosigma sp.
Melosira sp.
Navicula spp.
Nitzschia sp.
Plagiotropis sp.
Pleurosigma sp.
Stauroneis sp.
Surirella sp.
Synedra ulna
Synedra spp.
Tabellaria sp.
Other species present:
Spirogyra sp.
Ulothrix sp.

Station 3, Quadrat 1

Cymbella sp.
Diatoma sp.
Eunotia sp.
Fragilaria sp.
Melosira sp.
Navicula spp.
Nitzschia sp.
Plagiotropis sp.
Pleurosigma sp.
Stauroneis sp.
Surirella sp.
Synedra spp.
Other species present:
Ulothrix sp.

Station 3, Quadrat 3

Eunotia sp.
Fragilaria sp.
Melosira sp.
Navicula spp.
Nitzschia sp.
Plagiotropis sp.
Stauroneis sp.
Synedra spp.
Other species present:
Ulothrix sp.

Station 3, Quadrat 4

Coscinodiscus sp.
Fragilaria sp.
Gyrosigma sp.
Melosira varians
Melosira sp.
Navicula spp.
Nitzschia sp.
Plagiotropis sp.
Stauroneis sp.
Synedra ulna
Synedra spp.
Other species present:
Ulothrix sp.

Table 8. Physical and chemical parameters measured at three stations in the Pamet River, February 28, 1985.

Station	pH	Temp. (°C)	Conductivity (µmhos/cm)	Dissolved oxygen (mg/l)	Dissolved carbon dioxide (mg/l)	Bicarbonate (mg/l)	Carbonate (µg/l)	Acidity*	Chloride (mg/l)
1	6.6	2.3	903	11.6	1.29	12.20	2.98	3.5	58.8
2	6.6	3.2	1518	11.8	1.38	13.42	3.69	4.0	88.4
3	6.5	4.4	2760	12.8	1.52	14.64	3.49	2.5	287.9

*Expressed as mg $CaCO_3$ per liter.

Station	Iron (mg/l)	Sulfate (mg/l)	Aluminum (mg/l)	Ammonia (µg/l)	Nitrite (µg/l)	Nitrate (µg/l)	Phosphorus		Silicon (mg/l)
							Inorganic (µg/l)	Total (mg/l)	
1	0.56	260.9	0.3	33.58	7.17	62.37	15.95	0.48	0.39
2	0.12	406.8	<0.2	54.86	6.01	32.66	15.02	0.33	0.25
3	0.25	785.4	<0.2	29.73	4.62	49.73	12.21	0.39	0.21

Table 9. Physical and chemical parameters measured at three stations in the Pamet River, April 22, 1985.

Station	pH	Temp. (°C)	Conductivity (μmhos/cm)	Dissolved oxygen (mg/l)	Dissolved carbon dioxide (mg/l)	Bicarbonate (mg/l)	Carbonate (μg/l)	Acidity*	Chloride (mg/l)
1	7.2	12.6	209	9.0	0.87	14.64	18.60	5.0	157.3
2	6.4	12.6	632	6.2	1.17	12.81	2.68	4.0	174.8
3	6.7	13.1	1162	9.7	1.68	21.35	9.24	4.5	212.8

*Expressed as mg $CaCO_3$ per liter.

Station	Iron (mg/l)	Sulfate (mg/l)	Aluminum (mg/l)	Ammonia (μg/l)	Nitrite (μg/l)	Nitrate (μg/l)	Phosphorus		Silicon (mg/l)
							Inorganic (μg/l)	Total (mg/l)	
1	0.35	227.5	0.2	13.03	5.45	24.78	20.01	0.29	0.27
2	1.05	170.6	0.1	18.80	5.34	25.81	13.14	0.27	0.39
3	1.27	1259.4	<0.1	32.99	8.00	35.31	22.83	0.29	0.40

Table 10. Benthic macroinvertebrates found in samples from three locations in the Pamet River, February 28, 1985.

Station 1

Phylum Nemertea n = 1

Phylum Annelida

Class Oligochaeta

Family Naididae n = 15

Phylum Arthropoda

Class Insecta

Order Odonata

Family Coenagrionidae (damselflies) n = 1

Order Diptera

Family Chironomidae (midges) n = 14

Station 2 (replicate 1)

Phylum Annelida

Class Oligochaeta

Family Naididae n = 1

Phylum Arthropoda

Class Crustacea

Order Isopoda

Family Asellidae n = 1

Class Insecta

Order Diptera

Family Chironomidae n = 11

Station 2 (replicate 2)

Phylum Annelida

Class Oligochaeta

Family Naididae n = 18

Phylum Arthropoda

Class Insecta

Order Diptera

Family Chironomidae n = 14

Station 3

Phylum Arthropoda

Class Insecta

Order Diptera

Family Chironomidae n = 34

Table 11. Benthic macroinvertebrates found in samples from three locations in the Pamet River, April 22, 1985.

Station 1

Phylum Annelida
- Class Oligochaeta
  - Family Naididae n = 12

Phylum Arthropoda
- Class Crustacea
  - Order Amphipoda
    - Family Talitridae
      - *Hyalella azteca* n = 2
- Class Insecta
  - Order Ephemeroptera (mayflies)
    - Family Baetidae n = 1
  - Order Diptera
    - Family Chironomidae n = 1

Station 2

Phylum Annelida
- Class Oligochaeta
  - Family Naididae n = 1

Phylum Arthropoda
- Class Insecta
  - Order Diptera
    - Family Chironomidae n = 6

Station 3

Phylum Annelida
- Class Oligochaeta
  - Family Naididae n = 1

Phylum Arthropoda
- Class Crustacea
  - Order Amphipoda
    - Family Talitridae
      - *Hyalella azteca* n = 1
- Class Insecta
  - Order Diptera
    - Family Tipulidae (crane flies) n = 7
    - Family Chironomidae n = 19
    - Family Ceratopogonidae (biting midges) n = 1

Table 12. Physical and chemical parameters measured at six primary wells, A - F, in the Pamet River, February 28, 1985.

Primary well	pH	Temp. (°C)	Conductivity (µmhos/cm)	Dissolved oxygen (mg/l)	Acidity*	Chloride (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Aluminum (mg/l)	Ammonia (µg/l)	Nitrate (µg/l)	Phosphorus		Silicon (mg/l)
												Inorganic (µg/l)	Total (mg/l)	
A	6.2	8.9	87	3.5	17.5	28.9	0.20	139.0	0.6	16.58	1196.9	13.77	0.17	0.11
B	NOT SAMPLED													
C	6.1	11.6	121	5.4	8.0	40.2	0.12	49.9	<0.2	10.22	447.9	42.19	0.18	0.28
D	5.1	5.0	242	5.6	18.0	45.0	0.16	148.4	0.2	120.20	1141.0	4.08	0.16	0.08
E	5.8	9.9	171	8.4	8.5	40.8	0.09	60.1	<0.2	8.45	24.8	8.14	0.20	0.12
F	5.5	12.0	241	6.0	10.0	43.5	0.17	77.5	<0.2	21.01	18.6	5.33	0.16	0.11

*Expressed as mg $CaCO_3$ per liter.

Table 13. Physical and chemical parameters measured at six primary wells, A - F, in the Pamet River, April 22, 1985.

Primary well	pH	Temp. (°C)	Conductivity (μmhos/cm)	Dissolved oxygen (mg/l)	Acidity*	Chloride (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Aluminum (mg/l)	Ammonia (μg/l)	Nitrate (μg/l)	Phosphorus Inorganic (μg/l)	Phosphorus Total (mg/l)	Silicon (mg/l)
A	6.0	11.1	192	2.6	18.5	25.7	0.41	145.3	< 0.1	62.40	1226.2	23.45	0.17	0.24
B	6.4	10.0	101	**	6.0	47.3	0.29	48.8	< 0.1	14.80	114.8	13.77	0.10	0.11
C	6.3	12.6	116	4.9	9.5	45.2	0.25	64.9	< 0.1	52.05	344.3	35.01	0.21	0.25
D	5.6	7.0	59	2.8	18.5	60.7	0.30	143.0	0.4	60.04	865.4	23.14	0.20	0.09
E	6.1	11.3	45	7.2	9.5	59.6	0.34	73.5	< 0.1	12.00	25.7	7.21	0.16	0.10
F	5.7	11.6	226	6.8	10.0	64.8	0.74	86.5	0.1	53.09	13.2	5.02	0.15	0.16

*Expressed as mg $CaCO_3$ per liter.

**Malfunction.

Table 14. Physical parameters measured at six secondary wells, G - L, in the Pamet River, February 28, 1985.

Secondary well	pH	Temperature (°C)	Conductivity (umhos/cm)
G	6.0	12.2	109
H	NOT SAMPLED - WELL DRAINED FOR WINTER		
I	5.9	11.5	155
J	NOT SAMPLED - WELL DRAINED FOR WINTER		
K	*	4.7	2280
L	*	5.4	8680

*Malfunction.

Table 15. Physical parameters measured at six secondary wells, G - L, in the Pamet River, April 22, 1985.

Secondary well	pH	Temperature (°C)	Conductivity (umhos/cm)
G	6.3	12.5	114
H	6.3	8.2	118
I	6.3	10.9	146
J	5.9	9.5	140
K	7.7	9.8	2320
L	7.7	10.6	6290